

An automatic detection method for the boiler pipe header based on real-time image acquisition

Yi Long^{1,2}, YunLong Liu^{1,2,*}, Yongliang Qin³, XiangWei Yang^{1,2}, DengKe Li^{1,2} and DingJie Shen^{1,2}

¹State Grid Hunan Electric Power Company Research Institute, Changsha, China

²Hunan Xiangdian Test Research Institute Co.Ltd. Changsha, China

³Yuanyang Hu Power Plant, Shenhua Guoneng Energy Group Corporation Limited, Yinchuan, China

*Corresponding author e-mail: 13874809964@163.com

Abstract. Generally, an endoscope is used to test the inner part of the thermal power plants boiler pipe header. However, since the endoscope hose manual operation, the length and angle of the inserted probe cannot be controlled. Additionally, it has a big blind spot observation subject to the length of the endoscope wire. To solve these problems, an automatic detection method for the boiler pipe header based on real-time image acquisition and simulation comparison techniques was proposed. The magnetic crawler with permanent magnet wheel could carry the real-time image acquisition device to complete the crawling work and collect the real-time scene image. According to the obtained location by using the positioning auxiliary device, the position of the real-time detection image in a virtual 3-D model was calibrated. Through comparing of the real-time detection images and the computer simulation images, the defects or foreign matter fall into could be accurately positioning, so as to repair and clean up conveniently.

1. Introduction

The boiler pipe header is one of the most important of the thermal power plants [1]. It is necessary to detect the inner part of the boiler pipe header during A-type repair (usually every 5 to 8 years). Usually, an endoscope is used to test the inner part of the thermal power plants boiler pipe header [2-3]. However, since the endoscope hose manual operation, the length and angle of the inserted probe cannot be controlled. Besides, it has a big blind spot observation subject to the length of the endoscope wire. Additionally, it is difficult to determine the specific location of the endoscope probe [4-5]. Therefore, it is impossible to determine the position of the defects or foreign matter accurately [6].

In this paper, an automatic detection method for the boiler pipe header based on real-time image acquisition and simulation comparison techniques was proposed. The magnetic crawler with permanent magnet wheel could carry the real-time image acquisition device to complete the crawling work and collect the real-time scene image. According to the obtained location by using the positioning auxiliary device, the position of the real-time detection image in a virtual 3-D model was calibrated. Through comparing of the real-time detection images and the computer simulation images,



the defects or foreign matter fall into could be accurately positioning, so as to repair and clean up conveniently.

2. Principle of automatic detection system

The principle block diagram of the automatic detection system is shown in Fig. 1. The magnetic crawler with permanent magnet wheel could carry the real-time image acquisition device to complete the crawling work on the inner surface of the enclosed chamber. Then the image acquisition device is used to complete the real-time collection of the scene image of the enclosed chamber, and the positioning and distance measuring device is used to achieve the positioning of the crawler. According to the obtained location by using the positioning auxiliary device, the position of the real-time detection image in a virtual 3-D model was calibrated. Through comparing of the real-time detection images and the computer simulation images, the defects or foreign matter fall into could be accurately positioning, in order to clean up and eliminate system error conveniently without opening the cover of the hydropower turbine runner chamber.

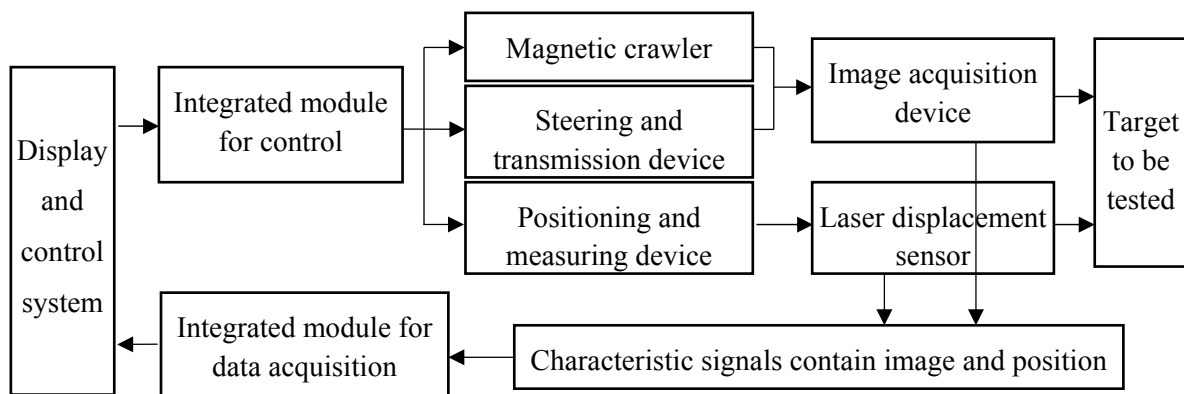


Figure 1. Principle block diagram of the automatic detection system

3. Principle and detection steps

The flow chat of the detection control system is shown in Fig. 2. The detection control system contains the motor control system and the data acquisition and processing system, which could realize the coordinated control of the motors and complete interactive communication with data acquisition and processing module. The detection control system contains 4 motors, and a half of them are used to control the motion of the magnetic crawler, and the others are used to achieve the perspective control of the image acquisition and illumination device.

Firstly, the magnetic crawler which carries the real-time image acquisition device and the positioning measuring device was put into the boiler pipe header. According to the collected positional parameters by using the positioning measuring device, the magnetic crawler could be positioned; according to the acquired angle parameters between the machine vision centerline and x-axis, y-axis and z-axis, the real-time acquisition feature image could be positioned.

Secondly, the virtual 3-D model of the boiler pipe header was established and the position of the corresponding feature image in the virtual model could be calibrated, according to the obtained positional parameters, the angle parameters and the structure parameters. Then, the real-time acquisition feature image and the corresponding feature image in the virtual model could be split-screen display in the computer control interface. At this time, once a foreign matter was detected by the image acquisition device, it would be displayed on the real-time image display screen. Through comparing of the real-time images and the virtual model, the corresponding virtual image with the same size virtual foreign matter would be displayed on another screen at the same time.

Finally, the position and size of the defects or foreign matters fall into the boiler pipe header could be obtained and be accurately calibrated, so as to repair and clean up conveniently.

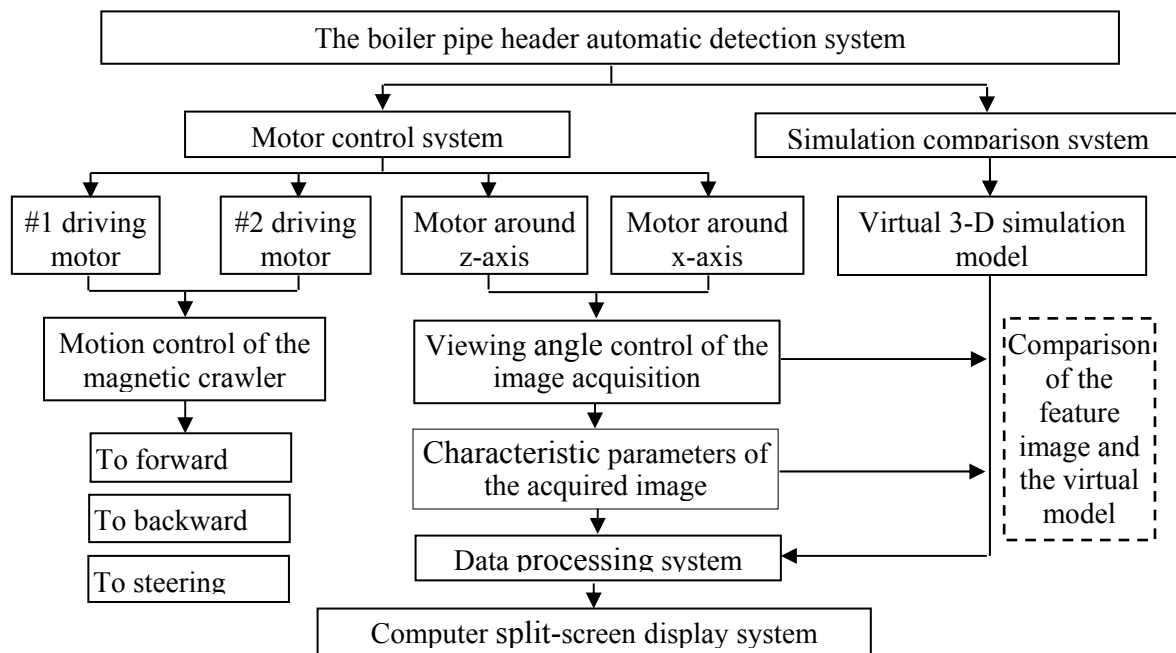


Figure 2. Flow chat of the detection control system

4. Application test

4.1. Processing magnetic crawler

The CAD design diagram and the processing physical photo of the magnetic crawler are shown in Fig. 3 and Fig. 4. A group of rechargeable batteries are used to supply energy, and the wireless wifi technology is used to achieve communication connection with computer control system, which has 40m effective signal transmission and apply to the detection of the structure of the inner flat and simple closed structure. The magnetic crawler has compact and airtight structure and be able to meet the testing requirements of the thermal power plants boiler pipe header.

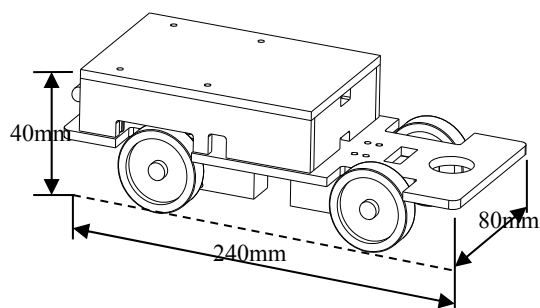


Figure 3. CAD diagram of magnetic crawler



Figure 4. Photo of wireless magnetic crawler

4.2. Detection of thermal power plants boiler pipe header

Generally, an endoscope is used to test the inner part of the thermal power plants boiler pipe header. However, since the endoscope hose manual operation, the length and angle of the inserted probe cannot be controlled. Additionally, it has a big blind spot observation subject to the length of the endoscope wire. Taking a high-temperature reheater outlet header of a thermal power plant as a testing example, its size parameters are $\Phi 914 \text{ mm} \times 90 \text{ mm} \times 18314 \text{ mm}$, as shown in Fig. 5.



Figure 5. Photo of boiler pipe header

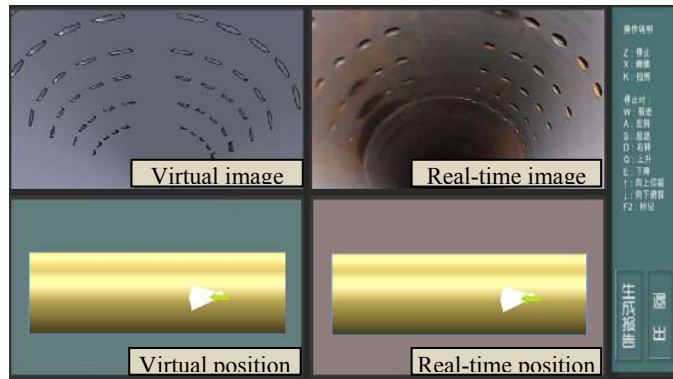


Figure 6. Split screen display interface of system

First of all, the virtual 3-D model of the high-temperature reheater outlet header must be established due to the actual structure and size parameters. And then, putting the wireless magnetic crawler into the entrance of the outlet header and connecting with the computer control system, the magnetic crawler was controlled to walk foreword. Meanwhile, the machine perspective in virtual model followed up according to the acquired real-time position parameters of the magnetic crawler. As a result, it was realized that the real-time acquisition of images and the virtual extract images split displayed comparably, as shown in Fig. 6.

In the high-temperature reheater outlet header, the magnetic crawler could complete the turn, U-turn and other actions. From the test results, it shows that the magnetic crawler has stable, reliable and well real-time operation, and detection system has clear image, stable signal and well synchronization transmission, to be suit for internal inspection of large-scale pipeline and boiler pipe header.

5. Conclusion

By proposing the automatic detection method, the problems of the existing testing methods for the thermal power plants boiler pipe header was improved significantly. The application test showed that the designed detection device could calibrate accurately and clean up the defects or foreign matter conveniently. According to the existing testing technical problems, such as the poor reliability, the larger detection blind spots and the short detection distance, it showed that the proposed detection method is effect and reliable.

Acknowledgments

This research was financially supported by the State Grid Hunan Electric Power Company (NO. 5216A514004A) and the Hunan Xiangdian Test Research Institute Co.Ltd. (NO.18).

References

- [1] HU Jiansheng and LIANG Leibo. The ultrasonic test of the narrow gap arc welding seam in thick-walled header of a 1000 MW power plant, NDT. 9 (2013) 66-68
- [2] SONG Shaohe and HAN Zhenhua. Ultrasonic testing of thick-wall header and pipe, NDT. 1 (2015) 79-80,95
- [3] ZHANG Liang. Analysis on Fault Handling Methods in Turbine Operation, China High Technology Enterprises. 32 (2015) 61-62
- [4] QU Zhao, ZHU Jianlin and LAI Xu. Study on hydroelectric generating unit on-line state monitoring system based on virtual instruments, Electric Power Construction. 2 (2005) 61-64.
- [5] DONG Baoguo. Detection of Transformer Oil Leakage Based on Image Processing, Electric Power Construction. 11 (2013) 121-124.
- [6] GAO Qiang and WEN Yao. Sag Calculation of Transmission Lines Based on Segmentation Image Analysis, Electric Power Construction. 11 (2010) 38-42.